Statistical models for pedestrian behaviour in front of bottlenecks

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Movement of pedestrian crowds

Movement of pedestrian crowds

wikimedia

1. How do individuals interact?

2. Do interactions differ across contexts?

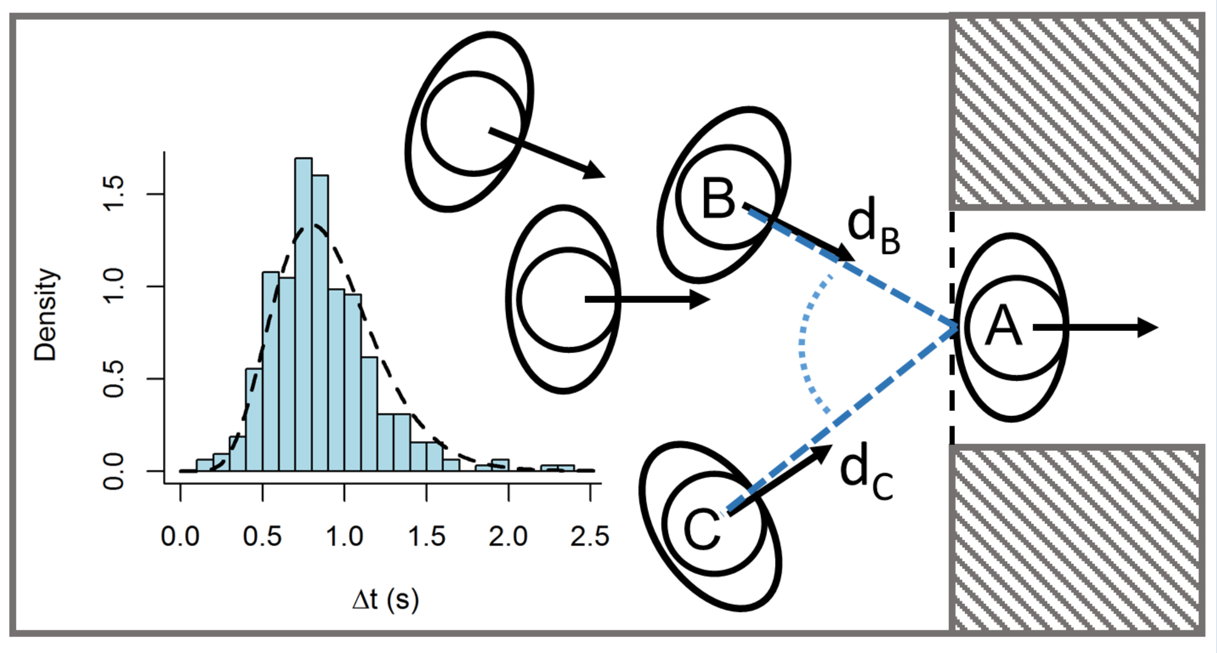
Focus on bottleneck scenario

1. How do individuals interact?

2. Do interactions differ across contexts?

Model microscopic interactions in front of bottleneck.

Time between consecutive pedestrians



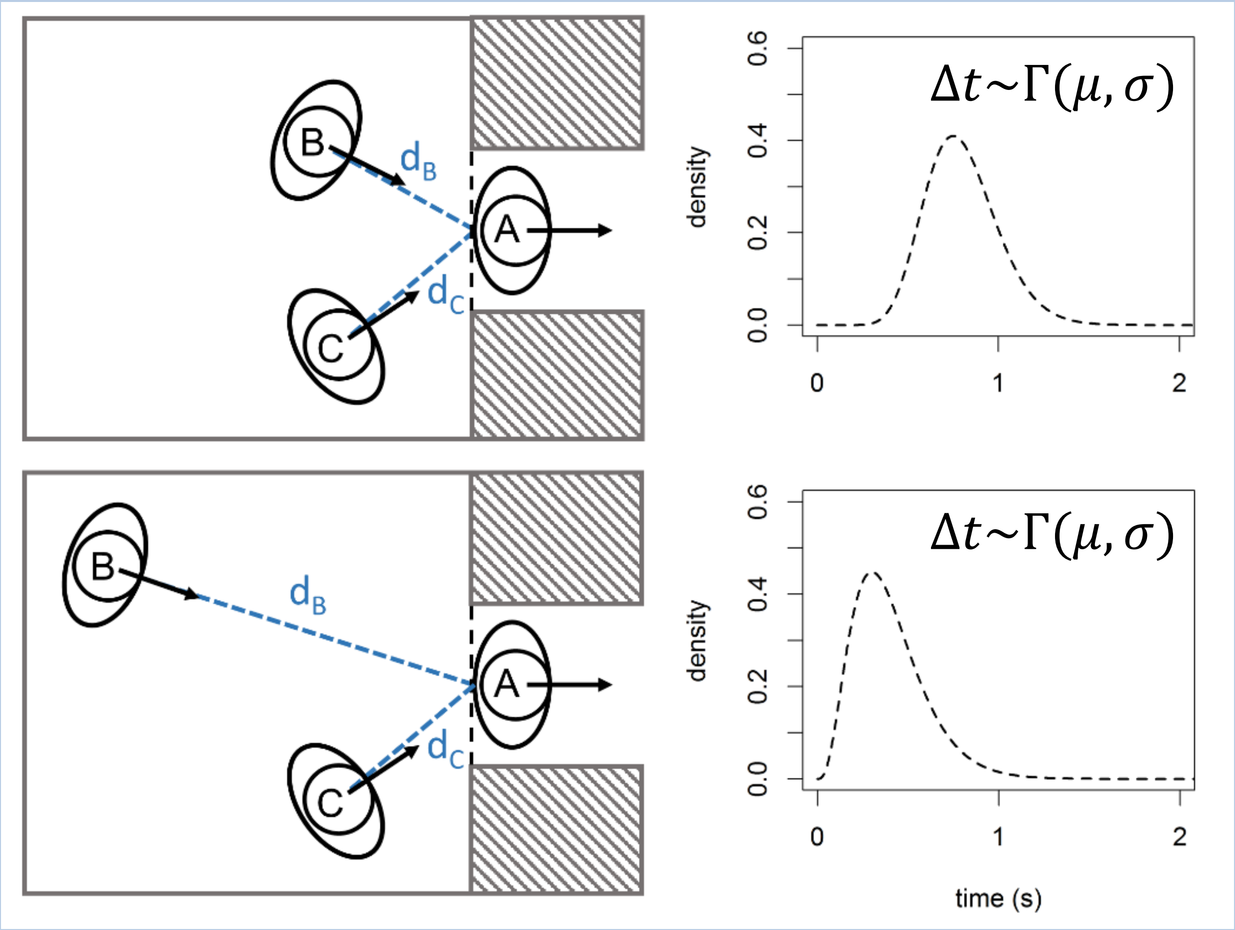
Statistical models:

$$\Delta t \sim \Gamma(\mu, \sigma)$$

e.g.

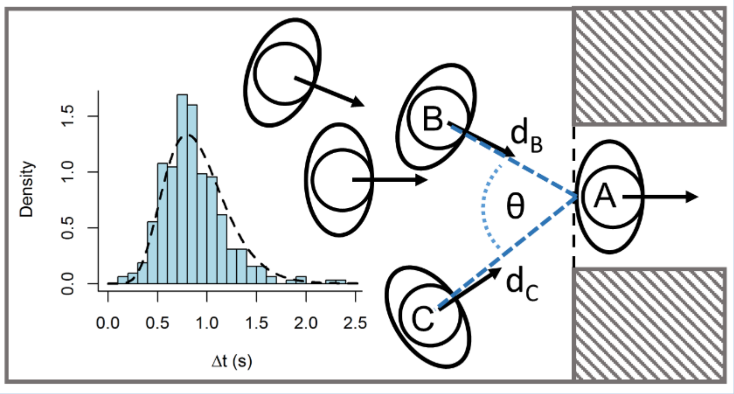
$$\mu = [p_1(d_C - d_B) - p_2]^2$$

Example



B
d_B
A
C
d_C
B
d_B
A
C
d_C
$\Delta t \sim \Gamma(\mu, \sigma)$
density
0.0
0.2
0.4
0.6
0
1
2
$\Delta t \sim \Gamma(\mu, \sigma)$
density
0.0
0.2
0.4
0.6
0
1
2
time (s)

Candidate models



Models for $\boldsymbol{\mu}$:

m_0: assume μ is constant

m_1: assume μ depends on density

m_2: assume μ depends on difference in distance between *B* and *C*

m_3: assume μ depends on angle between *B* and *C*

m_4: assume μ depends on distance of closest pedestrian

… consider combinations of models…

Model fitting

Statistical models: $\Delta t \sim \Gamma(\mu, \sigma)$

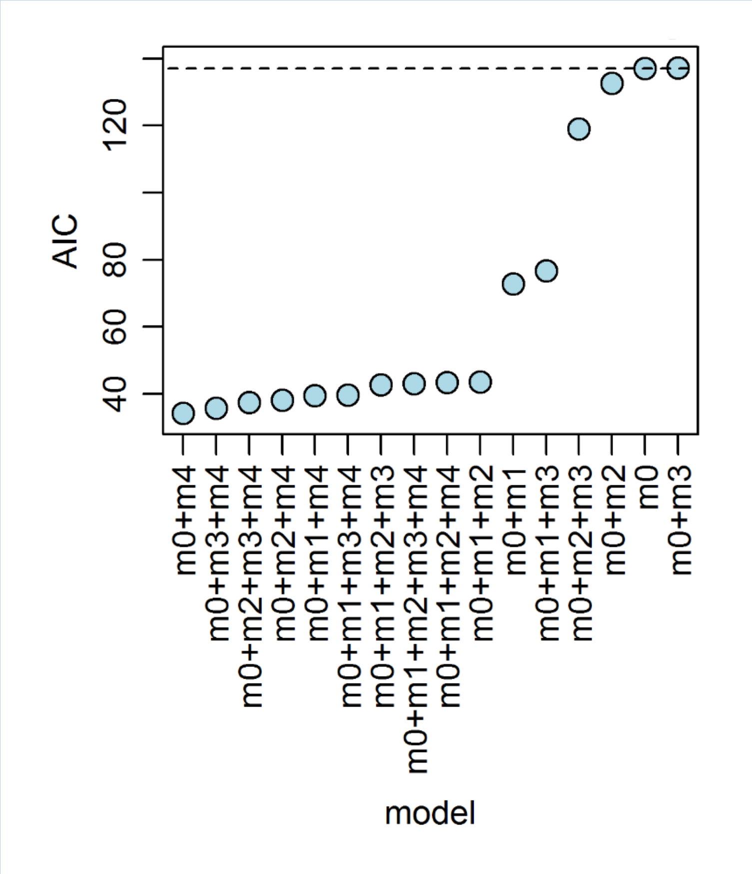
p.d.f. of gamma distribution: f_Γ

Likelihood of a model: $L = \prod_k f_\Gamma(\Delta t_k; \mu_k, \sigma)$

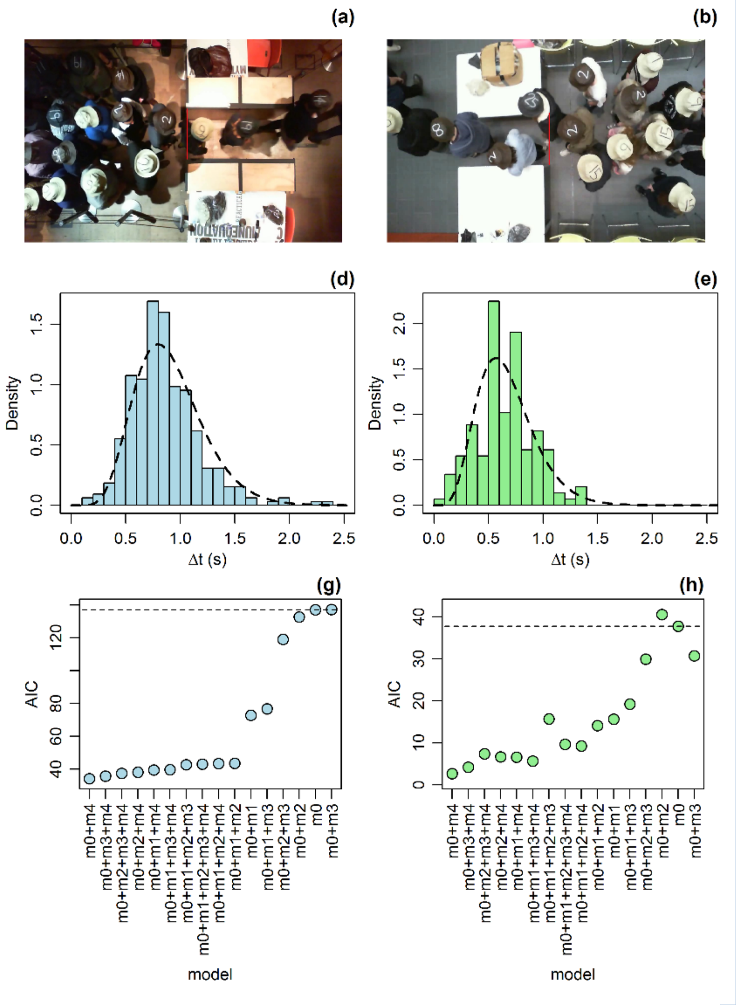
(assume models describe dependencies between consecutive Δt_k)

Find model parameters that maximise L.

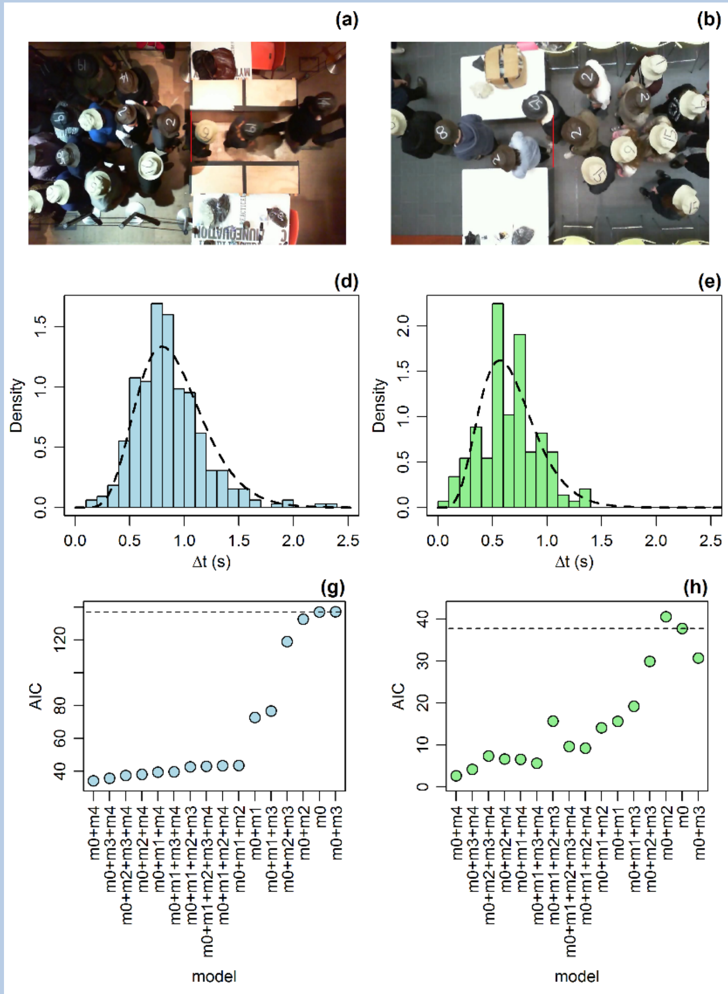
Model selection

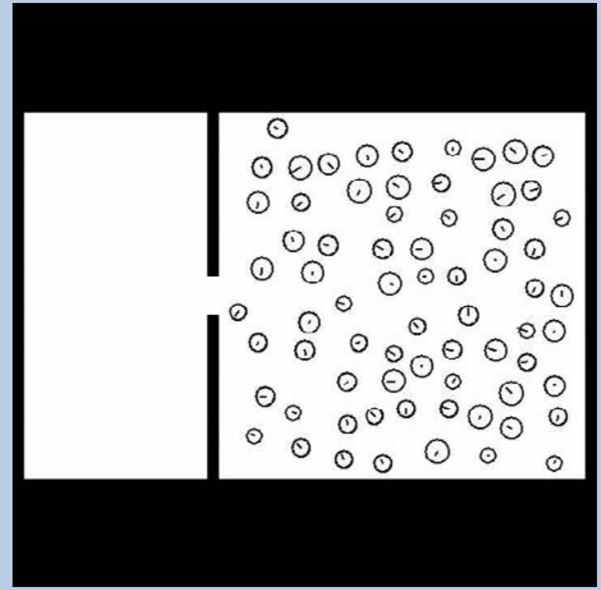


Comparing different contexts



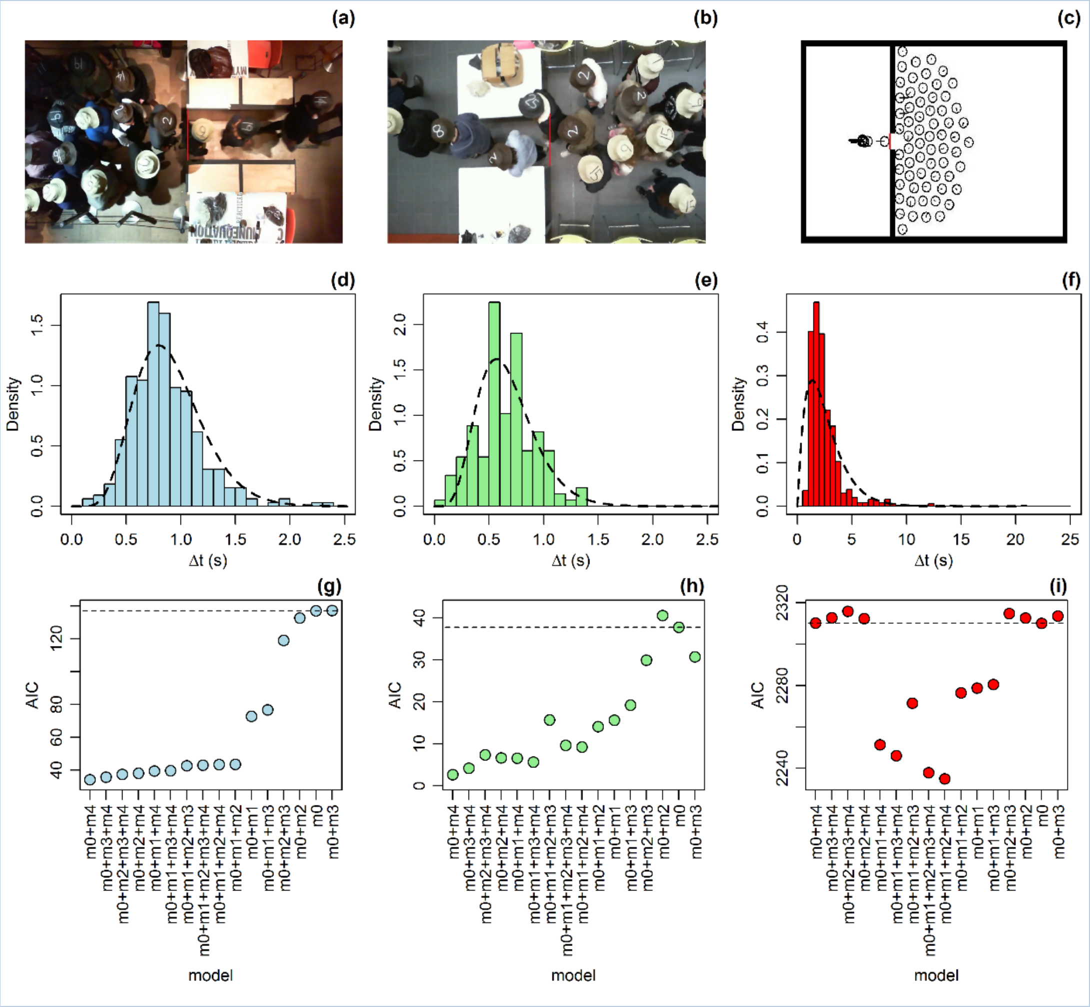
Comparing different contexts



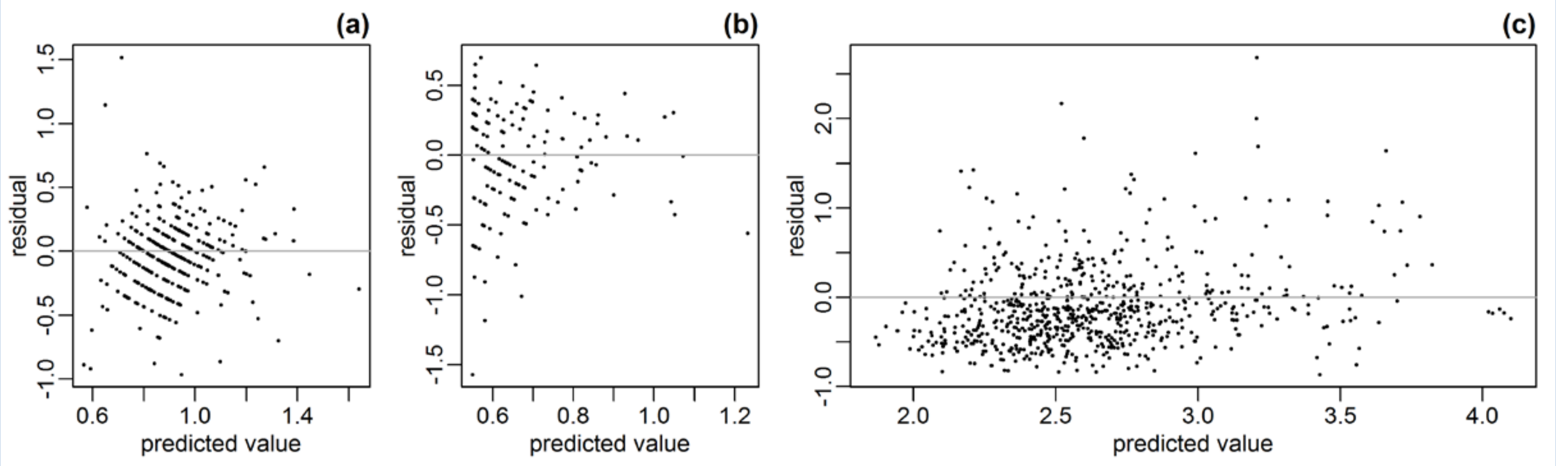


- Simulations are not fitted to experiments

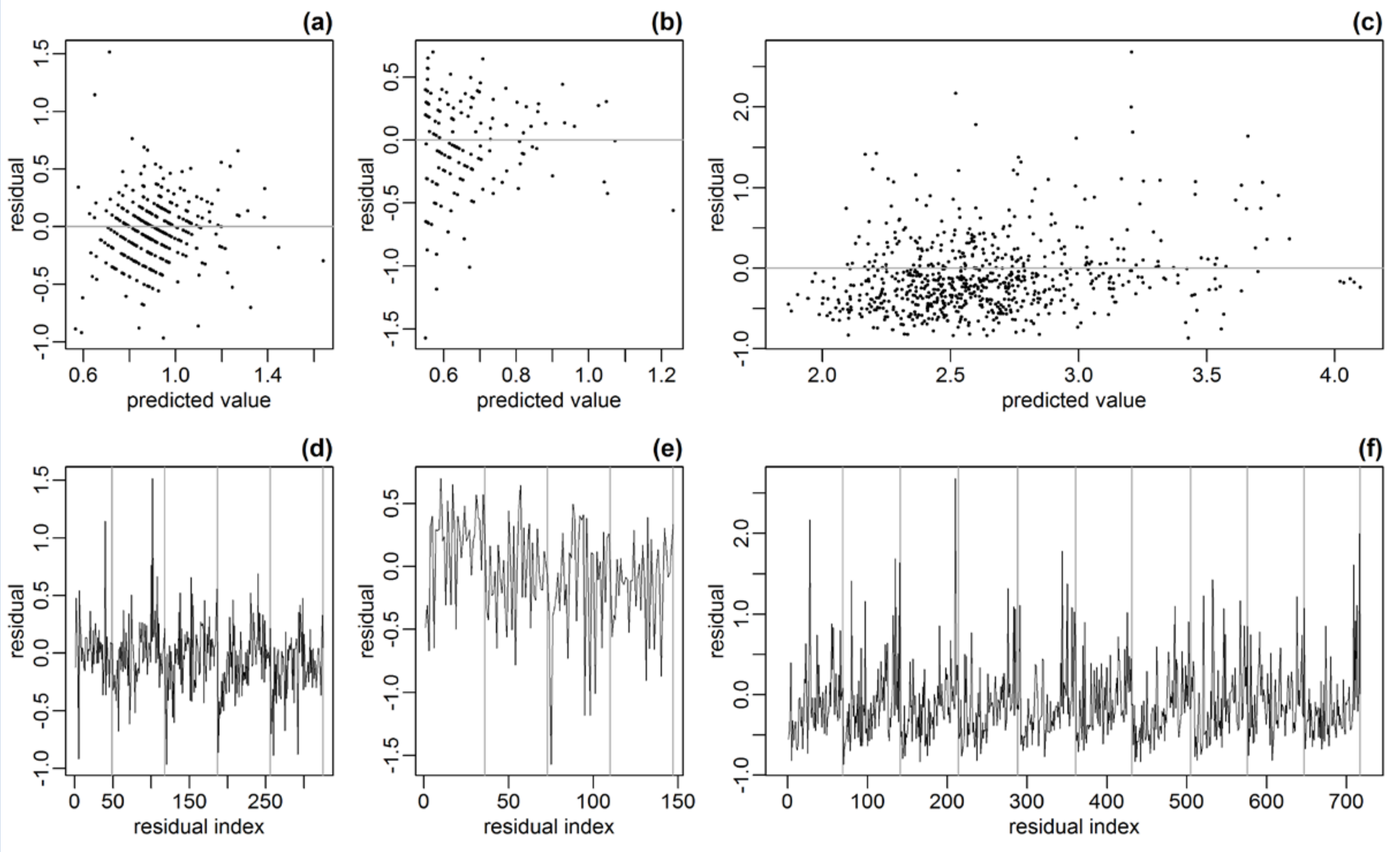
Comparing different contexts



Residual plots



Residual plots



Summary

- Can isolate most likely mechanism from candidates.
- Can use this to compare microscopic behaviour across contexts (*check simulation models*).
- Residual plots highlight aspects not explained by statistical models.

NOTE: if interactions inside bottleneck are important, the approach may not be appropriate.

Further work

- Framework is general and can be extended (e.g. social groups, age differences).
- Apply to a range of experiments/models.
- Consider wider exits.
- Investigate changes in behaviour over time.

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Thank you for listening!